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ATTORNEY'S DOCKET NUMBER: 20568-67235

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): Unknown 10/019364

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/US00/00105	04 January 2000	07 June 1999

TITLE OF INVENTION: DUAL HOMING FOR DWDM NETWORKS IN FIBER RINGS

APPLICANT(S) FOR DO/EO/US: OREN, Yair

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is attached hereto (required only if not communicated by the International Bureau).
   b. [ ] has been communicated by the International Bureau.
   c. [X] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [X] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (2 sheets)
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [XX] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [XX] Other items or information:
    1. Copies of the PCT International Search Report and Each Reference Cited Therein
    2. Copy of PCT International Preliminary Examination Report

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/019364 Unknown	PCT/US00/00105	20568-67235

21. ☐ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 710.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ -0-	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	57 - 20 =	37	x **$18.00**	$ 666.00	
Independent claims	1 - 3 =	-0-	x **$84.00**	$ -0-	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$ -0-	
TOTAL OF ABOVE CALCULATIONS =				$ 1376.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +				$ -0-	
SUBTOTAL =				$ 1376.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$ -0-	
TOTAL NATIONAL FEE =				$ 1376.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ -0-	
TOTAL FEES ENCLOSED =				$ 1376.00	
				Amount to be refunded:	$
				charged:	$

XX☒ A check in the amount of $ 1376.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 10-0435. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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REGISTRATION NUMBER

Express Mail No.: EL230047934US Mailed 25 October 2001 (25.10.01)

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group:	Unknown
Attorney Docket:	20568-67235
Applicant:	OREN, Yair
Invention:	DUAL HOMING FOR DWDM NETWORKS IN FIBER RINGS
U.S. Serial No:	Unknown
International. Serial No:	PCT/US00/00105
International Filing Date:	04 January 2000 (04.01.00)
Earliest Priority Date:	07 June 1999 (07.06.99)

FIRST PRELIMINARY AMENDMENT

Attention: DO/EO/US
Box PCT
Commissioner for Patents
Washington, D.C. 20231

Sir:

Preliminary to the examination of the above-identified national patent application submitted herewith, applicant requests entry of the following amendments.

Abstract

Please enter the Abstract of the Disclosure submitted as a separate paper herewith without reference numbers.

In the Description

After the title, please insert the following paragraph:

Cross-References to Related Applications

This application is a U.S. national counterpart application of international application serial No. PCT/US00/00105 filed January 4, 2000, which claims priority to U.S. provisional application serial no. 60/137,983 filed June 7, 1999.

In the Claims

Please amend the claims as follows:

22. (Amended) The apparatus of claim 1 [, 3, 5, 7, 9 or 11] wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

24. (Amended) The apparatus of claim 2 [, 4, 6, 8, 10 or 12] wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

26. (Amended) The apparatus of claim 1 [, 3, 5, 7, 9 or 11] further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

27. (Amended) The apparatus of claim 2 [, 4, 6, 8, 10 or 12] further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

Please add the following new claims 28-57:

28. The apparatus of claim 3 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

29. The apparatus of claim 28 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

30. The apparatus of claim 5 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

31. The apparatus of claim 30 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

32. The apparatus of claim 7 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

33. The apparatus of claim 32 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

34. The apparatus of claim 9 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

35. The apparatus of claim 34 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

36. The apparatus of claim 11 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

37. The apparatus of claim 36 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

38. The apparatus of claim 4 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

39. The apparatus of claim 38 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

40. The apparatus of claim 6 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

41. The apparatus of claim 40 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

42. The apparatus of claim 8 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

43. The apparatus of claim 42 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

44. The apparatus of claim 10 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

45. The apparatus of claim 44 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

46. The apparatus of claim 12 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

47. The apparatus of claim 46 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

48. The apparatus of claim 3 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

49. The apparatus of claim 5 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

50. The apparatus of claim 7 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

51. The apparatus of claim 9 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

52. The apparatus of claim 11 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

53. The apparatus of claim 4 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

54. The apparatus of claim 6 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

55. The apparatus of claim 8 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

56. The apparatus of claim 10 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

57. The apparatus of claim 12 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

REMARKS

This Preliminary Amendment is being submitted to indicate the relationship of the subject U.S. national application to previously filed applications as required under 37 C.F.R. 1.78, and to delete multiply dependent claims. Copies of the amendment to the specification, the amended claims, and the newly submitted claims are provided on separate pages following the last page of this amendment.

No amendment is believed to go beyond the disclosure in the international application as originally filed.

With the entry of the foregoing amendments, the application is believed to be in condition for examination and allowance. Consideration of the claims, leading to their allowance and passage of the application to issuance, is respectfully requested.

Respectfully submitted,

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Attorney for Applicant

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Abstract of the Disclosure

First and second optical fibers carry information modulated on an optical carrier. Information modulated on the carrier is to be recovered and transmitted at a first node along the first and second optical fibers. The first node includes apparatus for receiving and transmitting the information. The apparatus for receiving and transmitting the information includes a first receiver for demodulating the information modulated on the optical carrier and carried on the first optical fiber, a second receiver for demodulating the information modulated on the optical carrier and carried on the second optical fiber, a transmitter for modulating the information on the second optical fiber, and a splitter for splitting the optical carrier carried on the first optical fiber. The splitter is coupled to the first optical fiber and the first receiver. A portion of the optical carrier is coupled to the first receiver and another portion of the optical carrier continues on the first optical fiber.

INDS02 MJE 410625

Cross-References to Related Applications

This application is a U.S. national counterpart application of international application serial No. PCT/US00/00105 filed January 4, 2000, which claims priority to U.S. provisional application serial no. 60/137,983 filed June 7, 1999.

22. (Amended) The apparatus of claim 1 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

24. (Amended) The apparatus of claim 2 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

26. (Amended) The apparatus of claim 1 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

27. (Amended) The apparatus of claim 2 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

28. The apparatus of claim 3 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

29. The apparatus of claim 28 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

30. The apparatus of claim 5 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

31. The apparatus of claim 30 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

32. The apparatus of claim 7 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

33. The apparatus of claim 32 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

34. The apparatus of claim 9 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

35. The apparatus of claim 34 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

36. The apparatus of claim 11 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

37. The apparatus of claim 36 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

38. The apparatus of claim 4 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

39. The apparatus of claim 38 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

40. The apparatus of claim 6 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

41. The apparatus of claim 40 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

42. The apparatus of claim 8 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

43. The apparatus of claim 42 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

44. The apparatus of claim 10 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

45. The apparatus of claim 44 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

46. The apparatus of claim 12 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

47. The apparatus of claim 46 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

48. The apparatus of claim 3 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

49. The apparatus of claim 5 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

50. The apparatus of claim 7 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

51. The apparatus of claim 9 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

52. The apparatus of claim 11 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

53. The apparatus of claim 4 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

54. The apparatus of claim 6 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

55. The apparatus of claim 8 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

56. The apparatus of claim 10 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

57. The apparatus of claim 12 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

DUAL HOMING FOR DWDM NETWORKS IN FIBER RINGS

Field of the Invention

This invention relates to networks. It is disclosed in the environment of dense wavelength division multiplexed (DWDM) networks, but is believed to be useful in other applications as well.

Background of the Invention

Referring to Fig. 1, DWDM networks 20 implemented over fiber rings 22 can carry diverse types of traffic such as, for example, SONET, ATM, IP, and so on. These networks 20 are capable of mixing different types of traffic in the same ring 22. A typical DWDM network 20 includes an arbitrary number of nodes 24 interconnected in a ring topology by a pair of optical fibers 26. One of the nodes 24 is designated the hub node 30. The other nodes 24 are referred to as terminal nodes 32. Each terminal node 32 uses one or more dedicated DWDM wavelengths $\lambda J, \lambda K, \ldots \lambda P$, $1 \leq J, K, \ldots P \leq N$, to communicate with the hub node 30. The hub node 30 has the capability to switch traffic from one wavelength $\lambda 1, \lambda 2, \ldots \lambda N$ to another. This permits communication between any pair of terminal nodes 32 on the network 20. The DWDM channel $\lambda 1, \lambda 2, \ldots \lambda N$ used to transmit traffic from the hub node 30 to a specific terminal node 32 over one of the fibers 26 is called a downlink. The DWDM channel $\lambda 1, \lambda 2, \ldots \lambda N$ of the same wavelength operating on the other fiber 26 used to transmit traffic from the terminal node 32 to the hub node 30 is called an uplink. The resulting network 20 is sometimes described as a virtual DWDM star network implemented over a fiber ring 22. The protocol used in the interaction between the hub node 30 and a specific terminal node 32 is arbitrary and independent of the protocol used by any other terminal node 32. Examples of protocols include the above-mentioned SONET/SDH, ATM and IP. Where different channels $\lambda 1, \lambda 2, \ldots \lambda N$ use different protocols, all channels $\lambda 1, \lambda 2, \ldots \lambda N$ may be assumed to be using a common protocol, for example, SONET/SDH framing, with the other protocols, for example, ATM, IP and so on, mapped into the assumed common protocol (SONET/SDH frames in this example). Both the hub node 30 and the terminal nodes 32 have the capability to effect the appropriate protocol processing on both incoming

and outgoing traffic. All nodes 24, including the hub 30, have local tributary interfaces which permit the connection of external equipment to the network 20.

A network 20 as describe above is expected to be extremely reliable and remain fully or at least partially operational despite faults of different types. Of special, although not exclusive, interest in the context of this application are the following types of faults: the failure of a transceiver in one of the nodes 24; a break or other malfunction in the physical fiber 26 that renders a segment of the ring 22 unusable; and, total or partial failure of the hub node 30.

Disclosure of the Invention

According to the invention, first and second optical fibers carry information modulated on an optical carrier between at least two nodes. At a first one of the nodes, information modulated on the carrier is to be recovered and transmitted. The first node includes a first receiver for recovering information from the optical carrier carried on the first optical fiber, a second receiver for recovering information modulated on the optical carrier carried on the second optical fiber, a transmitter for modulating the information on the second optical fiber, and a first splitter for splitting the optical carrier carried on the first optical fiber. The first splitter is coupled to the first optical fiber and the first receiver. The optical carrier carried on the first optical fiber is split by the first splitter. A portion of the optical carrier is coupled to the first receiver and another portion of the optical carrier continues on the first optical fiber.

Illustratively, the apparatus for receiving and transmitting the information includes a third receiver for recovering information modulated on the optical carrier carried on the second optical fiber, a fourth receiver for recovering information modulated on the optical carrier carried on the first optical fiber, a transmitter for modulating information on the first optical fiber, and a splitter for splitting the optical carrier carried on the second optical fiber. The splitter is coupled to the second optical fiber and the third receiver. A portion of the optical carrier is coupled to the third receiver and another portion of the optical carrier continues on the second optical fiber.

Illustratively, the apparatus includes a third node. The third node includes a fifth receiver for recovering information modulated on the optical carrier

and carried on the first optical fiber, a sixth receiver for recovering information modulated on the optical carrier and carried on the second optical fiber, a third transmitter for recovering information on the second optical fiber, and a third splitter for splitting the optical carrier carried on the first optical fiber. The third splitter is coupled to the first optical fiber and the fifth receiver. A portion of the optical carrier is coupled to the fifth receiver and another portion of the optical carrier continues on the first optical fiber.

Illustratively, the second node includes means for recovering the optical carrier from, and returning the optical carrier to, the first optical fiber.

Illustratively, the second node includes means for recovering the optical carrier from, and returning the optical carrier to, the second optical fiber.

Illustratively, the apparatus further includes a fourth node for recovering the optical carrier from, and returning said optical carrier to, the first optical fiber.

Illustratively, the fourth node includes means for recovering the optical carrier from, and returning the optical carrier to, the second optical fiber.

Illustratively, the first receiver and the second receiver are coupled to a selection function which selects between the optical carrier received over the first optical fiber and the optical carrier received over the second optical fiber.

Illustratively, the third receiver and the fourth receiver are coupled to a selection function which selects between the optical carrier received over the first optical fiber and the optical carrier received over the second optical fiber.

Brief Description of the Drawings

The invention may best be understood by referring to the following detailed description and accompanying drawings which illustrate the invention. In the drawings:

Fig. 1 illustrates a technique for overcoming the failure of a transceiver module in a fiber optic network;

Fig. 2 illustrates a technique for overcoming the failure of a transceiver in a fiber optic network having interconnected rings;

Fig. 3 illustrates a network constructed according to the invention;

Fig. 4 illustrates a characteristic of networks constructed as illustrated in Fig. 3;

Fig. 5 illustrates the logical topology of the characteristic illustrated in Fig. 4;

Fig. 6 illustrates a characteristic of networks constructed as illustrated in Fig. 3;

Fig. 7 illustrates certain functions of a system constructed according to the invention;

Fig. 8 illustrates a characteristic of networks constructed according to the invention;

Fig. 9 illustrates a high-level functional diagram of a component of a system constructed according to the invention;

Fig. 10 illustrates a high-level functional diagram of a component of a system constructed according to the invention;

Fig. 11 illustrates certain details of a system constructed according to the invention;

Fig. 12 illustrates certain details of a system constructed according to the invention;

Fig. 13 illustrates a characteristic of networks constructed according to the invention; and,

Fig. 14 illustrates a characteristic of systems constructed according to the invention.

Detailed Descriptions of Illustrative Embodiments

The failure of a transceiver module 34 can be overcome by having a second, redundant transceiver 34 in each node 24 for each wavelength accessed by that node 24. A degree of protection against fiber 26 breaks can be provided by having each node 24 transmit each of its associated wavelengths λJ, λK, . . . λP in both directions around the ring 26, and having the destination node 24 select the better copy. Thus, a combined solution for these problems may be to have two transceivers 34 at each node 24 for each wavelength accessed by that node 24, one receiving and transmitting in one direction (which will sometimes be referred to herein as

eastbound) around the ring 26, and the other receiving and transmitting in the other direction (which will sometimes be referred to herein as westbound) around the ring 22.

However, the failure of a hub node 30 still threatens the reliability of the network, since the hub node 30 affects both traffic around the ring 22 and the connection of the ring 22 to other parts of the network 20. An effective solution to the problem of failure of a hub node 30 is to provide a backup for the hub node 30 in the form of a second, redundant hub 30. Providing a second hub node 30 is referred to in the art as "dual homing." This application relates to a cost-effective implementation of dual homing in the environment of DWDM networks in fiber rings 22.

A solution to the above-described problems is to have at each node 24 two transceivers 34 per associated wavelength. The two transceivers 34 at each node 24 transmit to/receive from opposite directions, westbound and eastbound. Referring to Fig. 2, dual homing is employed where two rings 22-1 and 22-2 are interconnected to provide greater fault resiliency. Two diverse paths are provided from a node 24-x on a first one, 22-1, of the rings to a node 24-y on the second ring 22-2. A hub node 30 is provided at each interconnection between the rings 22-1 and 22-2. The second ring 22-2 may be a DWDM ring like the first, or may be, for example, a SONET ring. Duplicating an entire hub node 30 may be expensive, given the high cost of DWDM transmitters. It must be remembered that a hub node 30 terminates all DWDM wavelengths in the network and therefore potentially has a large number of transmitters.

A cost-effective method for implementing dual homing in this environment achieves a 50% reduction in the required number of transmitters compared to duplicating an entire hub node 30, without sacrificing the reliability of the network 20. Referring to Fig. 3, each terminal node 32 sends two copies of its traffic, one to each of two hub nodes 30 on the network. Each hub node 30 effects the cross-connect function on all terminal node 32 traffic. Traffic intended for other terminal nodes 32 on the same fiber optic ring 22 is sent on the corresponding downlinks, along with traffic originating in the hub node 30's tributaries. Traffic intended for the hub node 30's local tributary ports is forwarded to those ports. Each

terminal node 32 receives two copies of the downlink, one from each hub node 30, and selects the better received one using a conventional selection method.

In a dual-interconnection configuration, a hub node 30 is located at each interconnection point. Each terminal node 32 sends two copies of its traffic, one to each hub node 30. Each hub node 30 effects the cross-connect function on all terminal node 32 traffic. Traffic intended for other terminal nodes 32 within the same fiber optic ring 22 is sent on the corresponding downlinks. Each hub node, for example, hub node 30-1-1, on the transmitting ring, for example, ring 22-1, sends its copy of the inter-ring traffic to its matching interconnection hub node, for example, hub node 30-2-1, on the receiving ring, for example, ring 22-2. In the receiving ring 22-2, the destination terminal node 32 receives the traffic from both hub nodes 30 on its ring 22-2 and selects the better-received signal using a conventional selection method. This is illustrated in Fig. 4. This logical topology, which may be called a "dual-homed star" topology, is illustrated in Fig. 5.

In order to enhance the reliability of the illustrated system, it is desirable to have each hub node 30 receive both uplinks from each terminal node 32. In other words, each hub node 30 drops the uplink it receives, but also continues that uplink to the other hub node 30. This is illustrated in Fig. 6. Each hub node 30 selects the best received copy of each uplink using the selection method and uses the best received copy. When this topology is used, each hub node 30 receives at least one copy of each uplink even when a fiber cut or a failed transmitter disrupts the reception of the other uplink at that hub 30. Using this strategy, which is sometimes called "drop and continue" functionality, also enhances the robustness of a network including interconnected rings 22-1, 22-2. For example, such a network can withstand two simultaneous fiber cuts, one in each ring 22. Drop and continue functionality is used in SONET UPSR rings for these reasons. In SONET networks, the function is implemented electronically. The optical signal of the uplink is converted to an electrical signal and duplicated, one of the duplicate electrical signals becoming a "drop" signal and the other becoming a "continue" signal. The "continue" signal is then retransmitted using another transmitter 38 to the other hub node 30. A similar implementation could be used for hub nodes 30 in DWDM rings 22.

Fig. 7 illustrates functions of a hub node 30 for each DWDM wavelength. As may be appreciated, this approach requires two receivers 36 and two transmitters 38 per wavelength. The high cost of DWDM transmitters 38 can make such a strategy rather expensive. In order to eliminate one of the two transmitters 38 the illustrated approach employs optical drop and continue functionality. This is illustrated in Fig. 8. An optical coupler/splitter 40 is used to split the power of the arriving uplink. Some of the power is then directed to the local receiver 36 and the rest is continued to the other hub node 30. The need for a second transmitter 38 is thus overcome. This results in reducing by 50% the number of required transmitters 38 for the two hub nodes 30, while still meeting all the reliability requirements of the dual homing strategy. For example, the network is protected against the failure of a transceiver 34. Each terminal node 32 has two transceivers 34, and is able to send and receive even if one of them fails. Each hub node 30 has two receivers 36 per wavelength, and so is not affected by the loss of one of them.

The loss of a transmitter 38 in one of the hub nodes 30 will not disrupt traffic either, since the transmitter 38 in the other hub node 30 can still transmit the downlink to the destination terminal node 32. The network is protected against fiber 26 cuts. Each terminal node 32 receives two copies of its downlink on completely diverse paths. Likewise each hub node 30 receives two copies of each uplink on completely diverse paths. Thus, no single fiber cut can disrupt the interconnection of the two rings 22. The network is also protected against the loss of a hub node 30. The functions of each hub node 30 are substantially completely duplicated by the other hub nodes 30. Thus the network remains functional even when one of the hub nodes 30 fails partially or completely.

Fig. 9 illustrates a high-level functional diagram of terminal nodes 32. A processing subsystem 41 provides protocol processing appropriate to a particular application. Examples include SONET/SDH multiplexers and ATM multiplexers. The processing subsystem 41 provides electrical signals to an optical subsystem 42, to be transmitted as the uplink on (a) DWDM channel(s) λJ (, λK, . . . λP) associated with that terminal node 32, and receives electrical signals derived from the associated downlink DWDM channel(s) λJ (, λK, . . . λP). The processing subsystem 41 typically also has external ports of different types in order to connect external devices

which use the transport services of network 20. The optical subsystem 42 implements the optical add/drop function for the DWDM channel(s) λJ (, λK, . . . λP). It also incorporates the required transceivers 34. A control subsystem 44 manages, configures and monitors the operation of the processing and optical subsystems 41 and 42, respectively.

Fig. 10 illustrates a high-level functional diagram of a hub node 30. A processing subsystem 46 provides protocol-related processing functions such as the cross-connect/switching function and protocol processing for wavelengths λ1, λ2, . . . λN generated by hub node 30. In case of a SONET/SDH application, the processing subsystem 46 provides the functionality of a SONET/SDH cross-connect, as well as all SONET/SDH-related protocol processing. In the case of an ATM application, the processing subsystem 46 provides the functionality of an ATM VPX and the associated protocol processing. The processing subsystem 46 provides to an optical subsystem 48 an electrical channel for each DWDM channel λ1, λ2, . . . λN generated by node 30. The processing subsystem 46 receives the electrical signals derived from all incoming DWDM optical uplink signal λ1, λ2, . . . λN. The processing subsystem 46 typically also has external ports of different types in order to connect external devices which use the transport services of the network. The optical subsystem 48 has the capability to generate/terminate all the DWDM channels λ1, λ2, . . . λN being used in the network 20. The optical subsystem 48 incorporates multiplexing/ demultiplexing functionality for the DWDM channels λ1, λ2, . . . λN, as well as suitable transmitters and receivers. A control subsystem 54 manages, configures and monitors the operation of the processing and optical subsystems 46, 48, respectively.

Fig. 11 illustrates certain details of an implementation of a dual-homed DWDM ring 22. An optical add/drop multiplexer, or OADM, 60-1, 60-2 is able to drop a specific wavelength λD, $1 \leq D \leq N$, from a DWDM combined signal on the fiber and route the dropped wavelength λD to a DWDM transceiver module 34-1, 34-2, respectively. The optical signal having the same wavelength λD generated by the DWDM transceiver 34-1, 34-2, respectively, is inserted by the OADM 60-1,60-2, respectively, into the aggregate DWDM signal λ1, λ2, . . . λN on the fiber. Each OADM 60 is assigned to a specific DWDM wavelength λD, and passes all other wavelengths unaffected. OADMs 60 are commercially available from several

vendors. DWDM transceiver 34 is a set including a receiver 36 and a transmitter 38, both for a specific wavelength λD. The transmitter 38 transforms an electrical signal generated, for example, by the processing subsystem 41, into an optical signal at a wavelength λD. The receiver 36 transforms an optical signal at wavelength λD to an electrical signal and provides it to the processing subsystem 41. Such transmitters 38 and receivers 36 are commercially available from several vendors.

Fig. 12 illustrates an implementation of an optical subsystem 48 of the hub node 30 in a dual-hub configuration. A DWDM multiplexer 70-1, 70-2 multiplexes several optical signals, each having a different wavelength λ1, λ2, . . . λN, into a single fiber output. DWDM multiplexers 70 are commercially available from several vendors. A DWDM demultiplexer 72-1, 72-2 separates a DWDM signal carried on a fiber 26 and containing several optical channels, each of a different wavelength λ1, λ2, . . . λN, into separate channel outputs λ1, λ2, . . . λN on separate optical fibers 74. DWDM demultiplexers 72 are also commercially available from several vendors. An optical channel module, or OCM, 76-λL, $1 \leq L \leq N$, is provided for each wavelength λ1, λ2, . . . λN, respectively. Each OCM 76-λL incorporates one DWDM transmitter 38-λL and two receivers 36-λL-1 and 36-λL-2 for the corresponding wavelength λL. Such receivers 36-λL-1 and 36-λL-2 and transmitters 38-λL are commercially available from several vendors. There are two configurations of OCMs 76-λL, the eastern configuration 76-λL-E, and the western configuration 76-λL-W. Fig. 13 illustrates the western configuration OCM 76-λL-W. The incoming signals from two DWDM demultiplexers 72-1, 72-2 are coupled to the receivers 36-λL-1 and 36-λL-2. The resulting electrical signals are evaluated 84 for quality using, for example, the SONET overhead provisions, and the better quality one is provided to the processing subsystem 46. The western incoming signal is duplicated using a splitter 40, for example, an optical coupler, and transmitted to the eastern output. Again, this is an optical drop and continue operation. Such optical couplers 40 are commercially available from several vendors. The electrical signal provided by the processing subsystem 46 is transmitted on the western output. The description of the eastern configuration OCM 76-λL-E is identical to the western configuration OCM 76-λL-W, except that east and west are reversed. That is, the eastern incoming signal

is continued through a splitter 40 to the western output, and the signal generated by the transmitter 78-λL is sent to the eastern output.

Different OCMs 76 within the same hub node 30 can be configured differently. The choice of a configuration for a specific OCM 76 depends on the relative location of the associated terminal node 32 with respect to the two hub nodes 30. This is illustrated in Fig. 14. Terminal node 32-1 is located to the east of hub node 30-1 and to the west of hub node 30-2. Therefore the OCM 76-λL-E in hub node 30-1 associated with terminal node 32-1 will have an eastern configuration, while the OCM 76-λL-W in hub node 30-2 associated with terminal node 32-1 will have a western configuration. The result is that the copy of the signal transmitted by terminal node 32-1 in the direction of hub node 30-1 will be received by hub node 30-1 and continued to hub node 30-2 around the ring 22 in one direction. The copy of the signal transmitted by terminal node 32-1 in the direction of hub node 30-2 will be received by hub node 30-2 and continued to hub node 30-1 around the ring 22 in the other direction. Each hub node 30 will receive two copies of the signal generated by terminal node 32-1, one from each direction of the ring 22. Terminal node 32-2 is located to the west of hub node 30-1 and to the east of hub node 30-2. Therefore the OCM 76-λL-W associated with terminal node 32-2 in hub node 30-1 will have a western configuration. The OCM 76-λL-E associated with terminal node 32-2 in hub node 30-2 will have an eastern configuration.

CLAIMS:

1. In combination, first and second optical fibers for carrying information modulated on an optical carrier, at least two nodes at a first one of which information modulated on the carrier is to be recovered and transmitted, the first node including apparatus for receiving and transmitting the information, the apparatus for receiving and transmitting the information including a first receiver for recovering the information from the optical carrier carried on the first optical fiber, a second receiver for recovering information modulated on the optical carrier carried on the second optical fiber, a transmitter for modulating information on the second optical fiber, and a first splitter for splitting the optical carrier carried on the first optical fiber, the first splitter coupled to the first optical fiber and the first receiver.

2. The apparatus of claim 1 further including a third node, the third node including apparatus for receiving and transmitting the information, the apparatus for receiving and transmitting the information including a third receiver for recovering information from the optical carrier carried on the first optical fiber, a fourth receiver for recovering information from the optical carrier carried on the second optical fiber, a second transmitter for modulating information on the second optical fiber, and a second splitter for splitting the optical carrier carried on the first optical fiber, the second splitter coupled to the first optical fiber and the third receiver.

3. The apparatus of claim 1 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

4. The apparatus of claim 2 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

5. The apparatus of claim 3 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

6. The apparatus of claim 4 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

7. The apparatus of claim 1 wherein the apparatus for receiving and transmitting the information includes a third receiver for recovering information from the optical carrier carried on the second optical fiber, a fourth receiver for recovering information from the optical carrier carried on the first optical fiber, a transmitter for modulating information on the first optical fiber, and a splitter for splitting the optical carrier carried on the second optical fiber, the splitter coupled to the second optical fiber and the third receiver.

8. The apparatus of claim 2 wherein one of the first and third nodes includes a fifth receiver for recovering information from the optical carrier carried on the second optical fiber, a sixth receiver for recovering information from the optical carrier carried on the first optical fiber, a third transmitter for modulating information on the first optical fiber, a third splitter for splitting the optical carrier carried on the second optical fiber, the third splitter coupled to the second optical fiber and the fifth receiver.

9. The apparatus of claim 3 wherein the apparatus for receiving and transmitting the information includes a third receiver for recovering information modulated on the optical carrier and carried on the second optical fiber, a fourth receiver for recovering information modulated on the optical carrier and carried on the first optical fiber, a transmitter for modulating information on the first optical fiber, and a splitter for splitting the optical carrier carried on the second optical fiber, the splitter coupled to the second optical fiber and the third receiver.

10. The apparatus of claim 4 wherein one of the first and third nodes includes a fifth receiver for recovering information modulated on the optical carrier and carried on the second optical fiber, a sixth receiver for recovering information modulated on the optical carrier and carried on the first optical fiber, a third transmitter for modulating information on the first optical fiber, and a third splitter for splitting the optical carrier carried on the second optical fiber, the third splitter coupled to the second optical fiber and the fifth receiver.

11. The apparatus of claim 5 wherein the apparatus for receiving and transmitting the information includes a third receiver for recovering the information modulated on the optical carrier and carried on the second optical fiber, a fourth receiver for recovering information modulated on the optical carrier and carried

on the first optical fiber, a transmitter for transmitting information on the first optical fiber, and a splitter for splitting the optical carrier carried on the second optical fiber, the splitter coupled to the second optical fiber and the third receiver.

12. The apparatus of claim 6 wherein one of the first and third nodes includes a fifth receiver for recovering information modulated on the optical carrier and carried on the second optical fiber, a sixth receiver for recovering information modulated on the optical carrier and carried on the first optical fiber, a third transmitter for transmitting information on the first optical fiber, and a third splitter for splitting the optical carrier carried on the second optical fiber, the third splitter coupled to the second optical fiber and the fifth receiver.

13. The apparatus of claim 1 wherein the first receiver and the second receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

14. The apparatus of claim 2 wherein the first receiver and the second receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

15. The apparatus of claim 14 wherein the third receiver and the fourth receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

16. The apparatus of claim 3 wherein the first receiver and the second receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

17. The apparatus of claim 4 wherein the first receiver and the second receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

18. The apparatus of claim 17 wherein the third receiver and the fourth receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

19. The apparatus of claim 5 wherein the first receiver and the second receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

20. The apparatus of claim 6 wherein the third receiver and the fourth receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

21. The apparatus of claim 20 wherein the first receiver and the second receiver are coupled to a selection function which selects between the optical carrier from the first optical fiber and the optical carrier from the second optical fiber.

22. The apparatus of claim 1, 3, 5, 7, 9 or 11 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

23. The apparatus of claim 22 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

24. The apparatus of claim 2, 4, 6, 8, 10 or 12 wherein the second node includes means for recovering said optical carrier from, and returning said optical carrier to, the second optical fiber.

25. The apparatus of claim 24 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

26. The apparatus of claim 1, 3, 5, 7, 9 or 11 further including a third node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

27. The apparatus of claim 2, 4, 6, 8, 10 or 12 further including a fourth node for recovering said optical carrier from, and returning said optical carrier to, the first optical fiber.

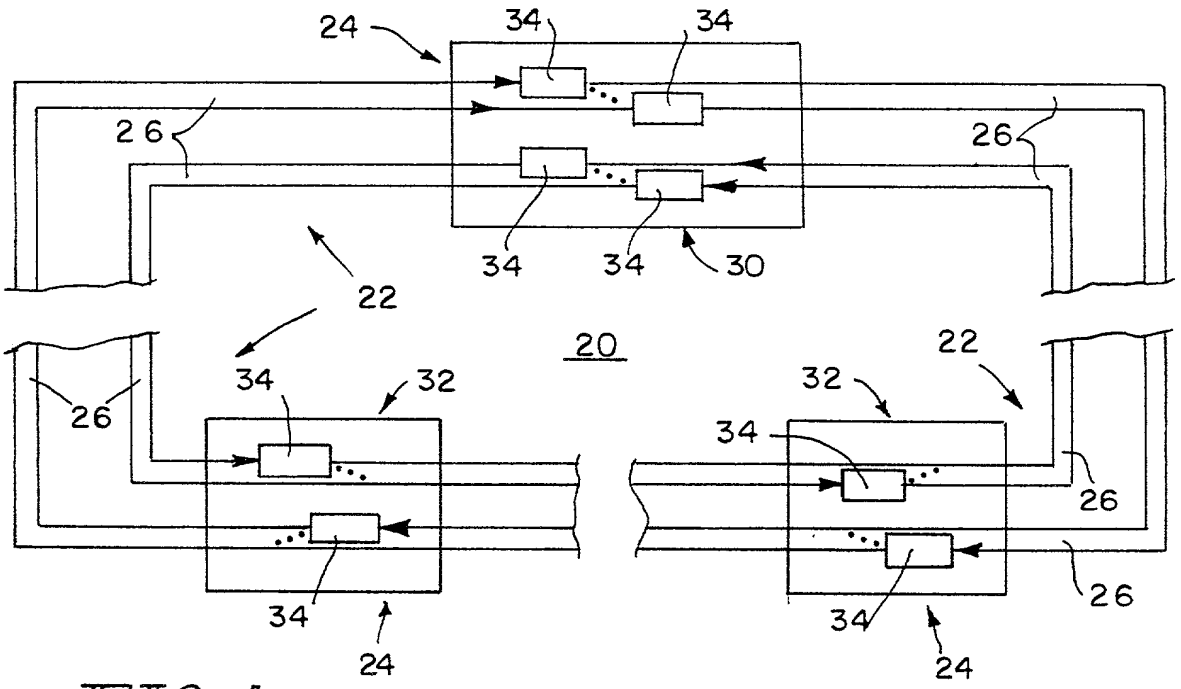

FIG. 1

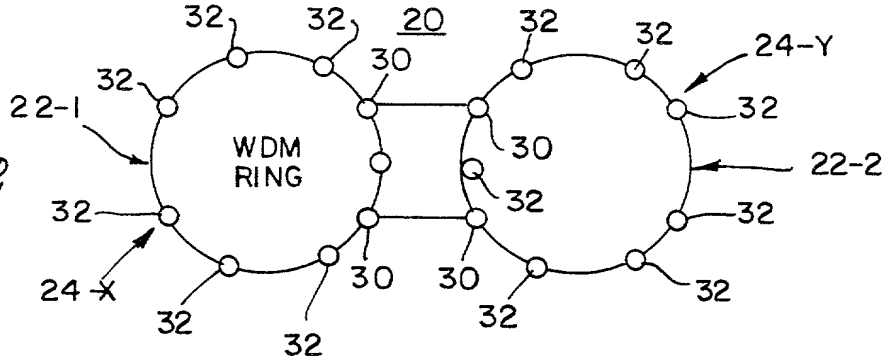

FIG. 2

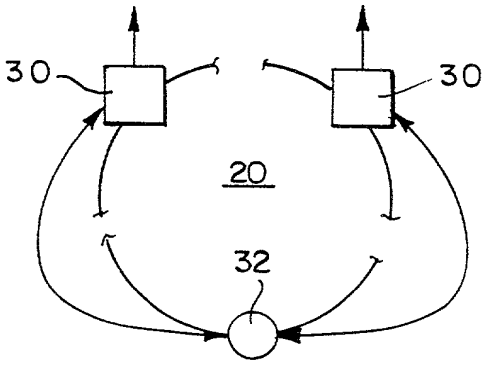

FIG. 3

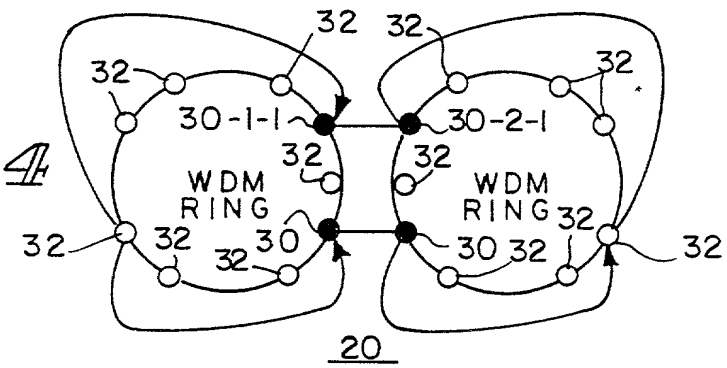

FIG. 4

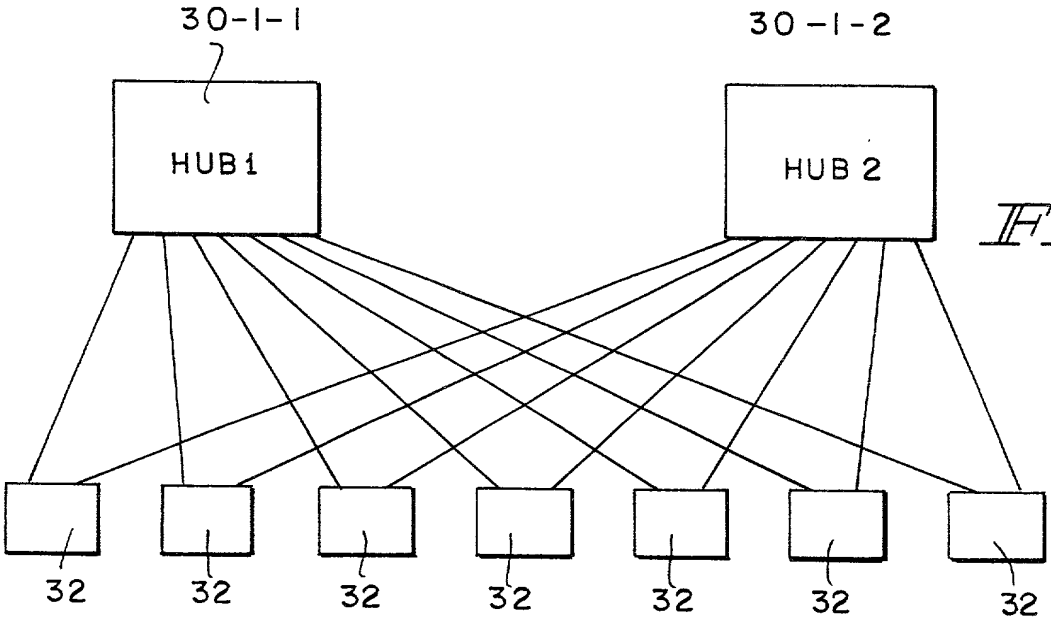

FIG. 5

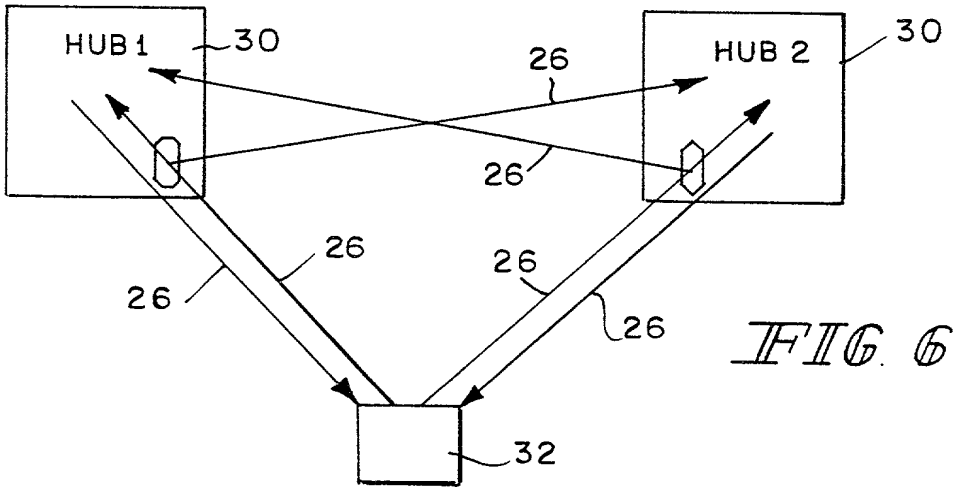

FIG. 6

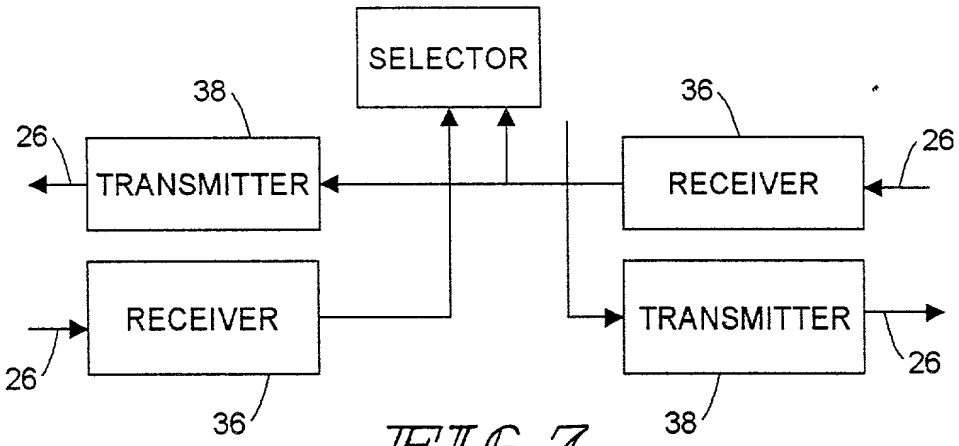

FIG. 7

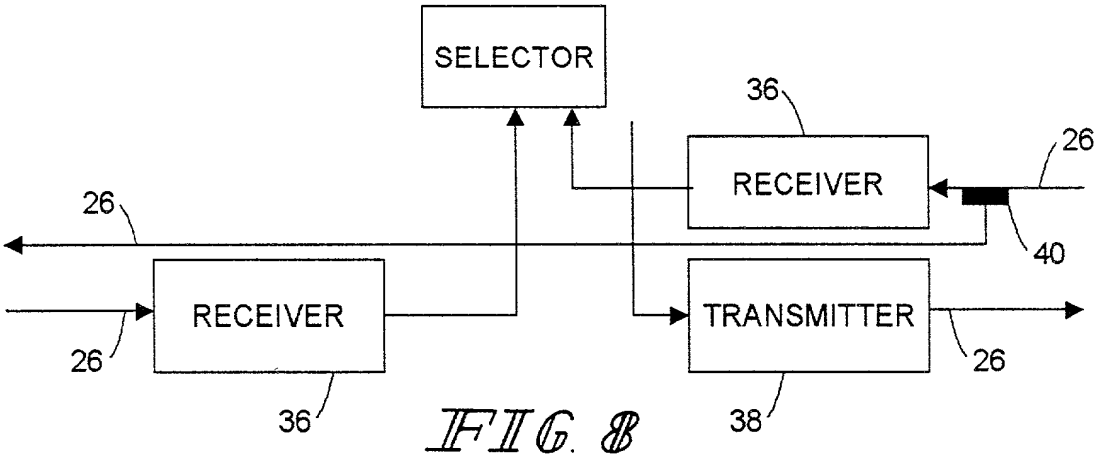

FIG. 8

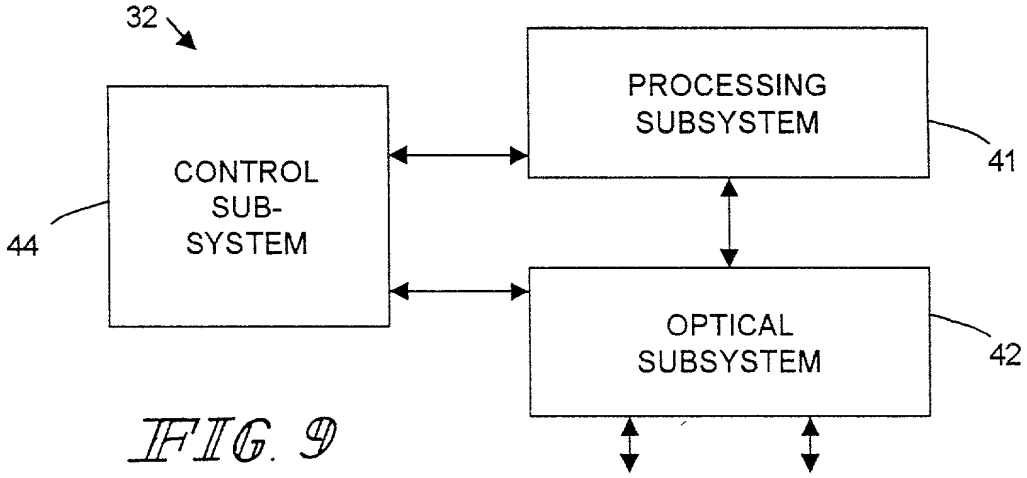

FIG. 9

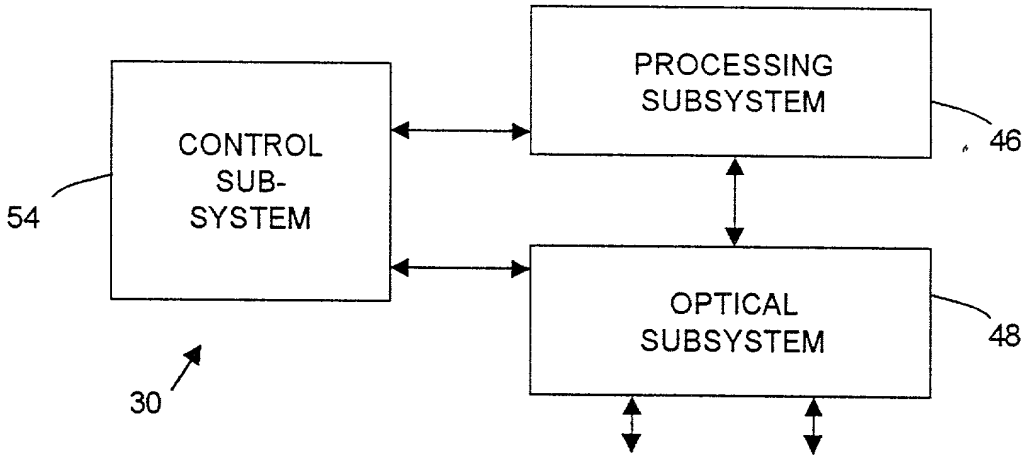
PROCESSING SUBSYSTEM
46
CONTROL SUB-SYSTEM
54
OPTICAL SUBSYSTEM
48
30

FIG. 10

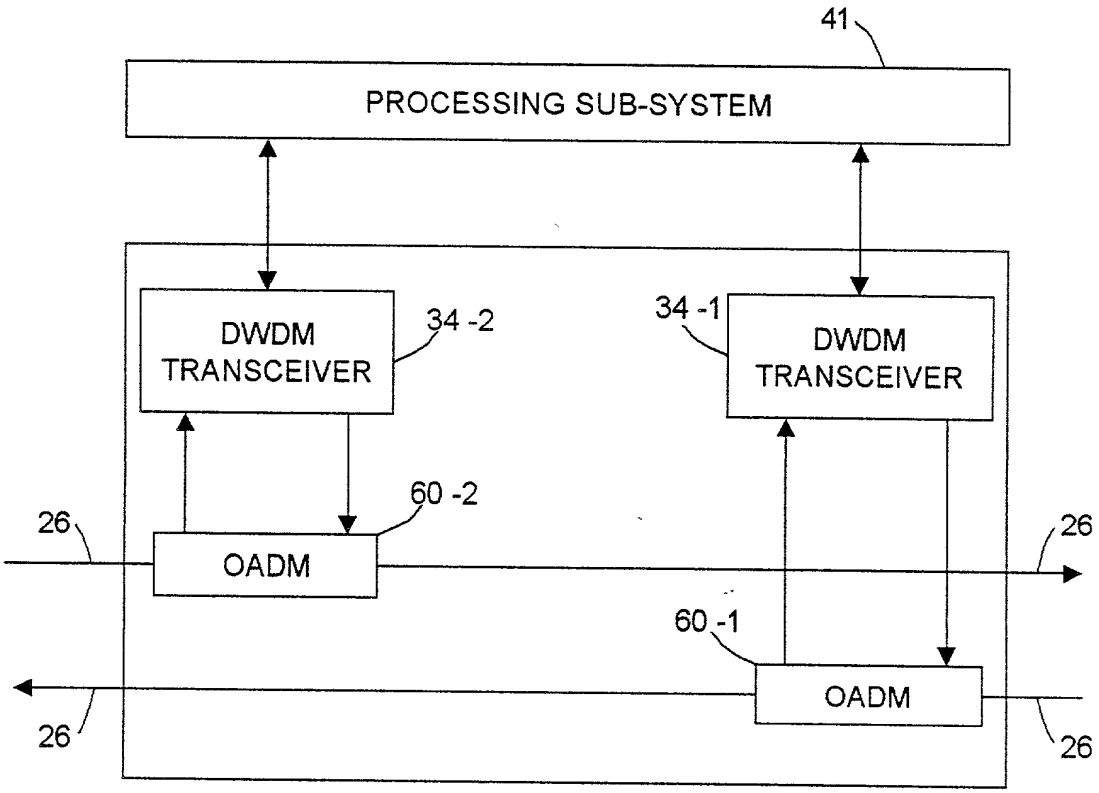
41
PROCESSING SUB-SYSTEM
DWDM TRANSCEIVER
34 -2
34 -1
DWDM TRANSCEIVER
60 -2
26
OADM
26
60 -1
OADM
26
26

FIG. 11

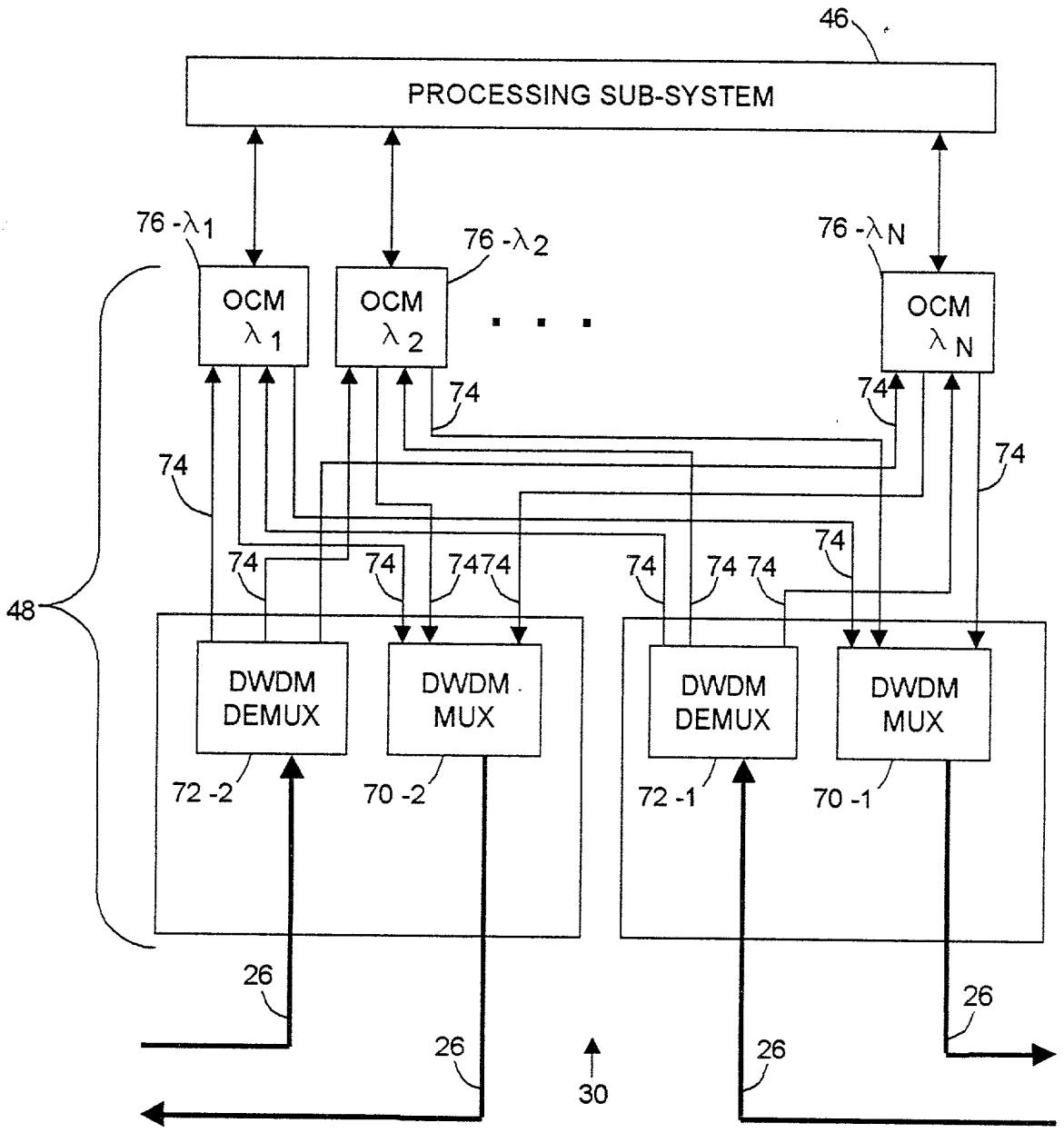

FIG. 12

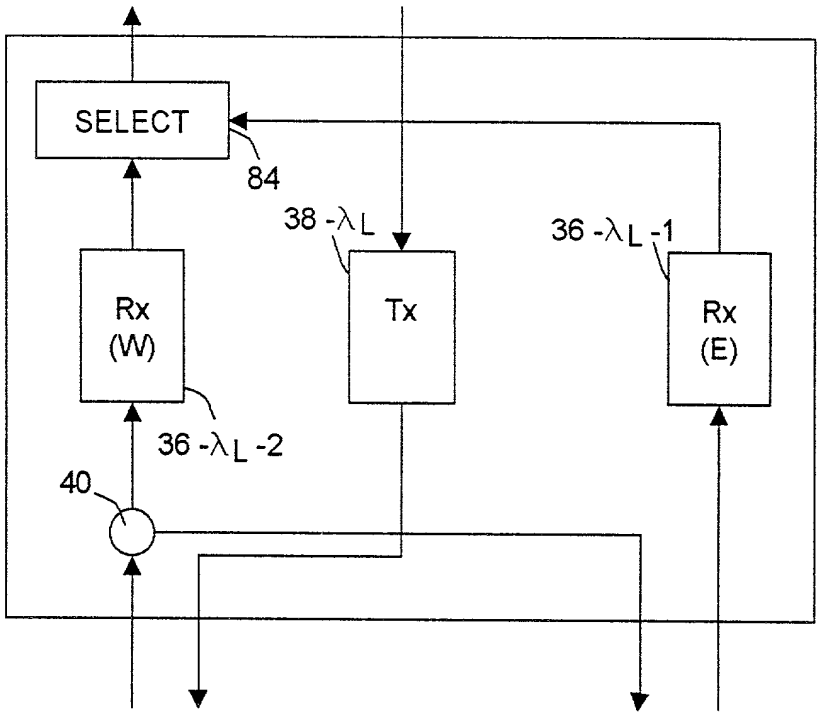

FIG. 13

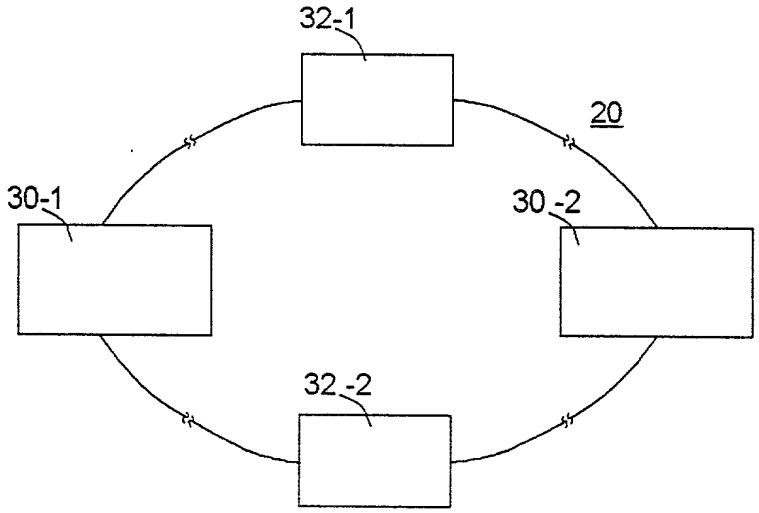

FIG. 14

Express Mail No.: EL230047934US

Attorney Docket No.: 20568-

DECLARATION AND POWER OF ATTORNEY -- PATENT APPLICATION

As a below named inventor, I hereby declare that I believe I am the original, first and sole inventor (*if only one name is listed below*) or an original, first and joint inventor (*if plural names are listed below*) of the subject matter which is claimed and for which a patent is sought in the application entitled:

DUAL HOMING FOR DWDM NETWORKS IN FIBER RINGS ,the

specification of which (*check one*)

_____ is attached hereto
XX was filed on 04 January 2000 (04.01.00) as
United States Application Serial No. _____ or
PCT International Application No. PCT/US00/
and was amended on _____
(if applicable)

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to herein.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) of any foreign application(s) for patent or inventor's certificate on which priority is claimed (as listed below) and I have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

60/137,983	07 June 1999 (07.06.99)
Application Number	Filing Date
Application Number	Filing Date

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(b) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status-patented, pending, abandoned
Application Serial No.	Filing Date	Status-patented, pending, abandoned

I hereby appoint William R. Coffey, Reg. No. 24023; Richard D. Conard, Reg. No. 27321; Steven R. Lammert, Reg. No. 27653; Richard A. Rezek, Reg. No. 30796; Timothy E. Niednagel, Reg. No. 33266; Nancy J. Harrison, Reg. No. 27083; R. Trevor Carter, Reg. No. 40549; Dilip A. Kulkarni, Reg. No. 27510; David B. Quick, Reg. No. 31993; Jill T. Powlick, Reg. No. 42088; Norman J. Hedges, Reg. No. 44151; Arland T. Stein, Reg. No. 28062; William B. Richards, Reg. No. 44301; Kenneth J. Waite, Reg. No. 45189; Thomas S. Reynolds II, Reg. No. 45262; Perry Palan, Reg. No. 26213; Mark M. Newman, Reg. No. 31472; Bobby B. Gillenwater, Reg. No. 31105; Paul B. Hunt, Reg. No. 37154; Michael S. Gzybowski, Reg. No. 32816; Gerard T. Gallagher,

Reg. No. 39679; Robert D. Null, Reg. No. 40746; Alice O. Martin, Reg. No. 35601; and Gregory S. Cooper, Reg. No. 40965, as attorneys of record with full power of substitution and revocation, to prosecute this application, and to transact all business in the Patent and Trademark Office connected therewith, and I specify that communications regarding the application be directed to:

BARNES & THORNBURG
11 South Meridian Street
Indianapolis, Indiana 46204
Telephone (317) 236-1313

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Yair Oren	Jan 17, 2000
Inventor's Signature	Date
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Second Inventor's Signature	Date
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Third Inventor's Signature	Date
Residence and Post Office Address	
Full Name of Fourth Joint Inventor, if any	Country of Citizenship
Inventor's Signature	Date
Residence and Post Office Address	

Additional inventors to be similarly identified on attached sheet.